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AN OVERVIEW OF THE TECHNOLOGY TRANSFER
SYSTEMS FOR SOIL AND WATER CONSERVATION
PRACTICES IN WESTERN CANADA AND
THE UNITED STATES

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This report is distributed as a working paper for those interested in Canadian agriculture. The findings and views do not necessarily represent the position of Agriculture Canada.

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The list of reports on this subject are as follows:

1. Agricultural Land Degradation in Western Canada: A Physical and Economic Overview
2. Prairie Agricultural Development Directions
3. How Specific Federal Policies May Impact on Prairie Soil and Moisture Conservation
4. United States Department of Agriculture Soil Conservation Activities on the U.S. Great Plains: Lessons for Agriculture Canada on the Canadian Prairies
5. Impacts and Program Delivery Aspects of Current Activities to Prevent Soil Degradation and Conserve and Improve Soil and Water Resources for Agriculture - Key Findings and Overview of Programs
6. An Overview of the Technology Transfer Systems for Soil and Water Conservation Practices in Western Canada and The United States

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Executive Summary

This report is one of a continuing series of studies related to regional development aspects of the Canadian agriculture and food system. In recent years farmers, agrologists and governments have become increasingly concerned with soil degradation problems in North America. The majority of farmers in North America use farming methods which are aimed at maximizing short-run productivity, often at the expense of farm practices which, if adopted, would alleviate soil degradation problems.

Unlike some single dimensional technologies such as new crop varieties, soil and water conservation measures are often complex and multi-dimensional and therefore require a comprehensive approach to technology transfer. This report which consists of eight sections, provides an overview of the complexities of transferring to farmers soil and water conservation measures.

A number of important findings related to soil and water technology transfer systems are discussed in the report. The major findings are:

- Physical factors such as topography, soil type and climate are important factors influencing the success of soil and water conservation measures. Technology transfer systems must account for the site specific aspects of conservation practices.
- The social-economic characteristics of farm operators are a major factor impacting on the adoption of soil and water conservation measures. Empirical studies, primarily undertaken in the United States have shown relationships between several socio-economic factors and adoption rates. The socio-economic characteristics of

age, education, income-levels and debt levels appear to be of particularly significant. The lack of such Canadian studies precludes any definite conclusions for western Canada and concentrated efforts should be made to verify these relationships since it has been shown that the adoption on behaviour differs across socio-economic groups.

- Economic studies in the United States have indicated large variations in the economic returns of conservation tillage systems. This variability is due to both physical factors and management skill. Studies of a similar type have not been undertaken in Canada.
- Non-government organizations are an active element of technology transfer systems in both the United States and Canada. These organizations however often lack the technical and financial resources for desired activities.
- In Western Canada, a number of government and non-government organizations are working on various aspects of soil and water conservation. A more systematic information transfer amongst the various government departments and non-government organizations would be beneficial to the adoption of soil and water conservation practices on the Prairies.
- In the United States technical advice on soil and water conservation is provided to farmers by the Soil Conservation Service. Staff of the Soil Conservation Service generally have specialized training in various aspects of soil conservation. On the Prairies, particularly in Saskatchewan and Alberta soil conservation practices are transferred to farmers primarily by extension staff who often have limited specialized expertise in soil conservation.

- The adoption rates of many soil conservation practices are low in both the United States and Western Canada. The available evidence however indicates that the adoption rates on the Northern Plains of the United States are higher than on the Canadian Prairies.
- A number of program approaches are available which could impact on the adoption of conservation measures. Program developes should evaluate program instruments against a number of criteria such as cost, complexity, ease of targeting and impacts on adoption rates.

The study concludes that the adoption of soil and water erosion control practices is a complex and dynamic process which perhaps is complicated by physical and socio-economic factors.

The study also outlines a number of conditions essential to the dissemination and adoption of soil and water conservation measures. These included:

- Technology is best transferred directly from the person to person; local people who are expected to use the techniques need to learn directly from those who have experience applying them.
- The technology needs to be adapted on site to local physical, economic, as well as social conditions.
- That agents of a technology transfer system must be knowledgeable and well qualified, while users must be receptive to the change .
- Most transfers also require a "facilitator"; who understands the technology transfer process, including the physical, social, and economic constraints involved.

- Both users and transfer agents should be involved in choosing the technologies and in planning and implementing the transfer process so that the technology meets the actual needs of the operator.
- The environment for demonstrations of the control measures should be similar to the environment that will exist for actual users. Pilot transfer projects should not be unrealistically easy or conducted under atypical conditions.
- The initial commitment of the resources to the process should be sufficient to carry the technology transfer until it is self-supporting or the risk is reduced to an acceptable level.
- The transfer process must include ways for all participants to evaluate the process and suggest improvements.

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I. INTRODUCTION

Although soil erosion and water quality have been recognized problems since the 1930's, recent interest in soil and water quality problems have generated considerable attention in Canada. It is generally felt that the continual deterioration of the agricultural land resource base may restrict the nation's ability to meet projected increases in food demand.

Rapid technological changes during the 60's and 70's resulted in an increase in the deterioration of the land resource base in North America. The major reason for this thrust in new agricultural technology was due to increased emphasis on short-run productivity increase. This resulted in the development of faster maturing and higher yielding varieties, increased use of and effectiveness of pesticides and chemical fertilizers. This was accompanied by larger and more specialized field equipment, excessive tillage operations and the increased use of land susceptible to the erosion process. Further, the practices of summerfallow in Western Canada compounded the problem. At the same time, not much emphasis was placed on the adoption of soil and water conservation measures.

The lack of recognition of soil erosion problems, short-run expediency and other important issues such as, increasing agricultural exports took precedence over the fundamental issues of conserving and protecting the land resource base. The non-adoption of conservation measures resulted in an apparent decline in the overall natural fertility and soil organic levels, combined with structural damage and increasing vulnerability of the land to erosion (Senate Committee on Agriculture, Fisheries and Forestry 1984). Further, the productivity growth rate increases from fertilizers, seed technology and pesticides are uncertain (Crosson 1981). These productivity trends, coupled with irreversible losses of agricultural land to urban and other uses and the possibility of increased demand for Canadian agricultural products, make the issue of conserving soil quality increasingly important.

There is no doubt that a large number of control measures are available to prevent or minimize soil erosion and salinization, however despite considerable expenditure on research, soil and water conservation control measures appear to have met with only partial success in terms of adoption rates. This paper is an overview of the technology transfer systems and those factors which influence the adoption and implementation of soil and water conservation measures in Western Canada and the United States.

II. FACTORS AFFECTING THE ADOPTION PROCESS

Resistance to change is always a frustrating experience to planners, educators and local officials. Lassey (1977) noted that frustration arises in part because we do not tend to adequately understand why individuals and social groups tend to resist change in technology by which tasks are accomplished. It is now evident that individuals or groups tend to prefer reasonable stability of circumstances in preference to dissonance resulting from alteration of behaviour pattern. Table 1 summarizes a number of characteristics of individual personality (A) and social factors (B) which provides the basis for resistance to the implementation process. If new ideas conflict with existing conceptions of what is valued, then individuals tend to reject the new possibility in favour of the old.

Table 1. Factors Associated with Resistance to Change

<u>(A) Personal Factors</u>	<u>(B) Social Factors</u>
1. Need for internal balance	1. Need to maintain social relationships and cultural coherence
2. Habit	2. Social norms or rules for accomplishing desired goals
3. Previous experience	3. Institutional or organizational historical experience
4. Limited ability to understand	4. Institutional or organizational blockage of threatening new information
5. Tendency to depend on traditional values and beliefs	5. Tendency to distrust nontraditional patterns of activity and responsibility
6. Tendency to prefer individual over group decisions: independence	6. Tendency of groups with a high stake in the status quo to prefer existing methods and priorities
7. Distrust of self-judgement in the face of group pressure	7. Distrust of outsider influence and behaviour contradictory to existing patterns
8. Insecurity and anxiety about the unknown	8. Group intolerance for untested or unexperienced patterns of action.

Source: Lassey, 1977. Planning in Rural Environments.

The reasons why farmers are reluctant to adopt soil and water conservation measures may thus be related to socio-economic factors rather than physical factors. Although the importance of socio-economic factors, as well as physical factors, for controlling soil erosion has been recognized (Earle et al. 1979) researchers of most soil conservation programs tend to concentrate on physical factors and ignore the socio-economic aspects. Prundeanu and Zwerman (1958) point out that, although the degree of erosion may be the same between farming units, producers will differ in implementation of soil conservation measures because of different socio-economic environments.

Sewell (1973) suggested that to achieve effective policy formulation, the beliefs, perception and attitudes of those likely to be affected by the decisions should be identified. Other researchers have also noted:

"An understanding of people and their social development is a prerequisite to achieving better land-use" (Hursh 1966).

"Modern concepts of soil and water conservation make it imperative that socio-economic factors be studied" (Rosenberry 1968).

"The success or failure of conservation methods depends on social attitude as much as anything" (Butzer 1974).

Thus, the task of implementing soil and water conservation measures should not be viewed as a simple matter of estimating the technical feasibility and the costs of construction and weighing them against anticipated revenues. The social system must be considered and integrated into any decision-making process affecting farmers.

The role of the various factors influencing the adoption behavior are individually identified and examined below.

Physical -

Control of soil and water to achieve desired conservation goals is related to the physical characteristics of the land. Land in terms of soil is not a homogenous unit and, as such, blanket recommendations without accounting

for the heterogenous characteristics of the land may result in failure. These heterogenous characteristics include, topography, soil and climatic conditions.

Blase and Timmons (1961) point out that ownership boundary lines in Western Iowa interfere with the practice of contouring and the construction of terraces. From a farmer's standpoint, terraces are too closely spaced, create very sharp curves and point rows, and are not consistent with the operating width of conventional farm machinery. The terrace length and space will, therefore, affect economic efficiency of production. It should be noted that terracing is not a common practice on the prairies.

Size of Operation-

Farm size can have different effects on the rate of adoption, depending on the characteristics of the technology and institutional setting. Research results in Kentucky have indicated that there is a positive relationship between farm size and conservation behavior (Coughenour and Kothari 1962). This positive relationship was substantiated by Timmons and Fischer (1963) in Iowa and Carlson et al. (1981) in Idaho. This relationship can be accounted for by the fact that operators of larger farms have more flexibility in their decision-making, access to available capital and perhaps the opportunity to experiment with the implementation of conservation practices on a small scale. Moreover, large fixed costs for soil conservation control measures can result in a reduced tendency to adopt and a slower rate of adoption on smaller farms. Further, Wagener et al. (1981) suggested that larger farms are better able to deal with risk and uncertainty often associated with new agricultural practices, specifically soil conservation practices.

Buttel et al. (1981) found a negative relationship between farm size and the adoption of soil and water conservation practices. These researchers maintain that operators of large farms are likely to create or ignore erosion problems compared with operators of smaller farms since large farm machinery are often incompatible with many conservation practices (e.g. terraces). Moreover, because larger farms tend to have higher debt levels, they will tend to seek short-term economic gains rather than the protection and the enhancement of the long-term viability of the land resource base.

Swanson (1974), found that in the Riding Mountain Till Plain of Manitoba, an area with severe erosion problem, most farms did not meet the necessary criteria for obtaining loans from local credit institutions. Small uneconomical farming units would have great difficulty in obtaining capital for farm improvement and, as such, access to credit may be a barrier to successful implementation of some soil and water control measures which require a substantial capital outlay.

Swanson (1974) also indicated that a farm size of under 210 acres would not be an economically viable unit in the Whitemud River Watershed in Manitoba and those units between 210 and 380 acres are only likely to be marginal. Table 2 indicates the number of farms in Western Canada in 1981. The percentage of farm units under 400 acres were 44.02 percent in Manitoba, 29.25 percent in Saskatchewan, and 44.89 percent in Alberta. In some instances small farms with limited resources may have difficulty purchasing conservation equipment.

Table 2: Number of Farms by Size in Western Canada, 1981

Farm Size (ac)	Manitoba	Saskatchewan	Alberta
(%)			
Under 3	250 (0.84)	264 (3.36)	321 (0.55)
3-9	532 (1.77)	241 (0.35)	589 (1.01)
10-69	1,832 (6.22)	1,189 (1.76)	3,352 (5.77)
70-239	5,389 (18.30)	7,438 (11.04)	12,426 (21.40)
240-399	4,975 (16.89)	8,577 (12.74)	9,383 (16.16)
400-559	4,113 (13.96)	7,718 (11.46)	6,844 (11.78)
560-759	3,875 (13.16)	9,314 (13.83)	6,404 (11.03)
760-1,119	4,293 (14.27)	13,510 (20.06)	7,600 (13.09)
1,120-1,599	2,352 (7.98)	10,012 (14.87)	4,978 (8.57)
1,600-2,239	1,123 (3.81)	5,190 (7.70)	2,849 (4.90)
2,240-2,879	387 (1.31)	1,858 (2.76)	1,222 (2.10)
2,880 and over	420 (1.42)	2,007 (2.98)	2,088 (3.59)

Income -

Studies in the United States by Ajaga (1980) and Carlson et al. (1981) suggested a positive relationship between farm income and the use or adoption of conservation practices since a need for immediate income is a barrier to the adoption of such practices. Individuals with low current incomes and the inability to obtain capital may not be willing to forgo short-term income in order to maximize expected net returns over a longer period (Lee 1980). Individuals in an uncertain economic situation will tend to use short planning horizons because they are unable to predict future costs and benefits. Swanson (1974) also found a similar relationship in Manitoba Riding Mountain Till Plain.

Lasley and Nolan (1981) found that farmers who tend to cooperate with soil conservation organizations have been found to have slightly higher incomes than non-cooperators. Statistics Canada is currently forecasting significant decreases in net farm income in Western Canada in 1984 (Table 3). In the medium term (1984-88) farm cash receipts for wheat are forecasted to increase by 2.5 percent annually which is considerably less than the 4.3 percent increase which is forecasted for total farm cash receipts (Borland and Robertson 1984). With relatively low net farm income, many farmers in Western Canada will be reluctant to undertake conservation practices which may require capital expenditures on specialized equipment.

Another important factor impacting on adoption rates is the source of income. On the prairies a significant proportion of full-time farmers earn a large portion of their income from off-farm sources (Table 4). In Manitoba 31.96 percent of the income earned is from off-farm sources compared with 27.81 percent in Saskatchewan and 33.78 percent in Alberta. This would perhaps imply that the operator would not be in a position to devote full attention to his operation and such an arrangement may not be conducive to proper implementation and monitoring of soil and water conservation measures. Macartney (1984), however, found no relationship between summerfallow intensity and off-farm work.

Type of Farm Operation -

Implementing soil and water conservation practices in most cases involves a change in the farming operation. For instance, inclusion of forage crop would imply that a grain farmer rear a few head of cattle, find a suitable market for the crop, or plough down the crop to enhance the soil productive capability. Inclusion of animal activities in the farming system would require year-round supervision, something which the farm operator might be reluctant to do. Further, Fast (1984) reported that agricultural technology, especially in the form of large machinery and crop specialization, has made certain conservation practices such as crop rotations and contour tillage economically unacceptable.

In Western Canada, a high percentage of farms are either wheat or small grain farm operations (Table 5). In Manitoba such farm types account for approximately 55 percent, in Saskatchewan 78 percent, and in Alberta it is 46 percent. It is perhaps unlikely that these farms would adopt soil conservation practices such as producing forages which would require significant changes in farm machinery and farm structure.

Table 3: Projected Net Farm Income, Prairies 1984

	Manitoba	Saskatchewan	Alberta
Crop Receipts	1060.0	3328.0	2053.2
Livestock Receipts	666.9	721.5	1770.4
Other Cash Receipts	24.5	24.6	22.2
Total Cash Receipts	1751.4	4074.1	2845.8
Income-in-kind	19.0	39.3	40.8
Realized Gross Income	1770.4	4113.4	3886.6
Operating Expenses	1308.5	2575.2	2636.1
Depreciation Charges	275.7	740.1	720.9
Total Operating and Depreciation charges	1584.2	3315.3	3357.0
Realized Net Income	186.2	798.1	529.6
Realized Net Income % Change 1984/83	-35.5	-8.9	-12.8

Source: Statistics Canada, Agricultural Statistics Division, July 1984

Table 4: Income From Farm and Off-Farm Sources in Western Canada, 1981

Source of Income	Manitoba		Saskatchewan		Alberta	
<u>All Farmers</u>						
	(\$)	(%)	(\$)	(%)	(\$)	(%)
Farm Income	3,732	(25.47)	8,750	(42.28)	3,857	(16.86)
Off-Farm Income	10,926	(74.53)	11,942	(57.71)	19,019	(83.13)
Net Income	14,658		20,692		22,876	
<u>Full Time Farmers</u>						
Farm Income	7,427	(68.03)	13,662	(72.18)	10,678	(66.20)
Off-Farm Income	3,490	(31.96)	5,265	(27.81)	5,449	(33.78)
Net Income	10,917		18,927		16,129	

Source: Statistics Canada 1981 Unpublished Data.

Table 5: Type of Farm Operation in Western Canada¹

Farm Size	Manitoba	Saskatchewan	Alberta
	(%)		
Dairy	1,803 (6.79)	1,623 (2.52)	2,743 (5.36)
Cattle	5,679 (21.41)	7,057 (10.96)	16,098 (31.46)
Hogs	1,011 (3.81)	632 (0.98)	1,402 (2.74)
Poultry	409 (1.54)	243 (0.37)	622 (1.21)
Wheat	6,105 (23.02)	11,096 (63.87)	7,738 (14.42)
Small Grains (excluding wheat farms)	8,533 (32.17)	10,162 (15.79)	16,493 (32.23)
Field Crops other than small grains	498 (1.87)	287 (0.44)	1,122 (2.19)
Fruits & Vegetables	88 (0.33)	28 (0.43)	76 (0.14)
Misc. Specialty	592 (2.23)	444 (0.69)	1,574 (3.07)
Livestock Combination	1,152 (4.59)	1,691 (2.62)	2,515 (4.91)
Field Crops Combination	107 (0.40)	10 (0.01)	112 (0.21)
Other Combinations	540 (2.03)	1,069 (1.66)	1,029 (2.01)

¹ Farms with sales of \$2,500 or more by product type.

Source: Agriculture Canada 1983. Selected Agriculture Statistics.
Canada and the Provinces, Government of Canada, Ottawa.

Profitability of Conservation Practices -

Several researchers Mitchell et al. (1980) in Illinois and Rosenberry et al. (1980) in southern Iowa have studied the net return on conservation investments. Most of these studies found that many conservation practices would not yield a profitable return to farmers. Mitchell et al. (1980), focussing on the direct costs and benefits to farms using terraces, found that most farmers would lose personal income by investing in such control measures. This was the case despite the government paying fifty percent of the construction costs.

However, no-till practices and other reduced tillage practices although involving the purchase of new equipment, in some cases do pay. For instance, Forster et al. (1976) found that no-till practices increased yields by 10 percent on well drained land. However, this was not the case on poorly drained lands. It is also expected that the amount of energy and labour used would be substantially reduced. Thus, while there appears to be positive financial inducements for some farmers to adopt no-till practices, the pay off will differ depending on soil type and climatic conditions.

In general, however, it is agreed that many soil conservation practices are not economically viable for the farm operator. The major exceptions, perhaps, are conservation tillage, contour ploughing and residue management. At most, these practices do not decrease the profitability, in some, they may even increase it. In Western Canada, the reduction of land in summerfallow has, in general, a positive impact on farm incomes in the black soil zone, a neutral effect in the dark brown soil zone and an adverse effect in the brown soil zone (Culver, 1984). However, there seems to be great variability with respect to the impacts on farm income with conservation tillage.

The variability in producers' returns is illustrated by examining the results of the Lost Creek demonstration project in Defiance County, Ohio (Defiance County Soil and Water Conservation District, 1983). As part of the demonstration project, an economic assessment was carried out comparing corn

and soybean plots planted in no-till systems with a conventional tillage system. Of the 48 plots which compared no-till to conventional tillage, producers' returns with no-till increased in 19 plots, decreased in 12 plots and remained relatively unchanged (less than five percent difference) in 17 plots. Although some of these differences are a result of management capabilities, other factors are clearly important since individual farmers had both income increases and decreases with no-till depending on field location.

Debt Level -

The level of farm debt affects the adoption of soil and water conservation measures in two ways. One, under high debt service requirements (e.g. land mortgages) operators are forced to plant more intensive crops such as corn which are erosion prone. Two, farmers with high debt levels find it difficult to finance conservation measures. Blase and Timmons (1961) found that debt servicing requirement was cited by the majority of farmers (60 percent) surveyed as a major obstacle to adopting conservation practices in western Iowa.

Planning Horizon -

It has been suggested that conservation measures (depending on type) have both short-term and long-term benefits. Short-term benefits can be associated with saving energy and labor as well as the reduction of off-site damages, whereas, long-term benefits are associated with protecting the productivity of the land resource base (Taylor et al 1981).

Because of the varying time periods associated with different types of benefits, the farmers discount rate and planning period can be important profitability determinants. Lee (1980) suggested that the discount rate and future plans to operate the present farm could influence decisions relating to the adoption of conservation practices. As such, long-term benefits would seem more attractive if the operator's plan also includes transferring the farm to other family members or selling the farm since in Saskatchewan saline land has a relatively lower value than those lands not affected.

Credit -

Access to capital in the form of either accumulated savings or capital markets is necessary in financing the adoption of erosion control practices. This differential access to capital is often cited as a factor affecting differential rates of adoption especially those control measures requiring large capital investment. These implications have been confirmed by Blase and Timmons (1961).

The availability of credit varies significantly amongst farm operators in Western Canada. A number of provincial farm credit programs are available to farmers which provide various levels of assistance with different eligibility requirements. Access to credit is also dependent on such factors as debt to equity ratios, farm size and off-farm income sources.

Tenure:

The farmer's legal status relative to the land operated is another important factor relative to the adoption of water and erosion control measures.

Early studies (Fry 1952) have found that tenancy arrangements are very important in explaining the adoption or non-adoption of erosion control measures. Since then, Dillman et al. (1978), Ajaga (1980), and Schertz and Wunderlich (1982) have found similar relationships. The rationale being that owners, unlike tenants, tend to employ these practices because they are likely to reap the long-term economic benefits. Further, owners are likely to benefit directly from economic incentives associated with conservation practices (Cook 1981). This is consistent with Easter and Cotner's (1982) findings that ownership is related to conservation investment.

Carlson et al. (1981) suggested that other explanations to this relationship could be the longer planning horizons for owner-operators than for tenants and problems in communications and joint decision-making between landlords and tenants.

These results however, are quite different from those reached by Lee (1981) who concluded that the separation of farm ownership from farm operation should not significantly inhibit adoption.

On the prairies the most common form of tenure is ownership (Table 6) with approximately 54.6 percent of the farm operators being farm owners in Manitoba, 50.7 percent in Saskatchewan and 57.6 percent in Alberta. Tenant farms account for less than 10 percent of the farms in each prairie province. This suggests that tenancy should not be a major inhibiting factor to soil conservation in the prairies.

Table 6: Land Tenure in Western Canada

Type	Manitoba	Saskatchewan (%)	Alberta
Owner	16,083 (54.62)	34,135 (50.71)	33,850 (57.58)
Tenant	2,259 (7.67)	5,980 (8.88)	3,675 (6.63)
Part-Owner	11,100 (37.70)	27,203 (4.40)	20,538 (35.36)

Source: Statistics Canada 1981

With respect to summerfallow, McCartney's 1984 study of summerfallow in Western Canada showed no association between tenure and summerfallow intensity.

Age -

Several studies, including those by Swanson (1974), Hoover and Wiitala (1980), and Lasley and Nolan (1981), have shown that age of the operator is related to the adoption of conservation practices. It appears that younger farmers perceive erosion as a problem, and conservation practices as being profitable and are therefore more willing to accept financial risk that might be associated with erosion control measures.

Seitz and Swanson (1980) argue that older farmers are not particularly concerned with the future impact of current practices. Heady (1965) noted that the older the farmer, the less likely he would accept the burden of additional debt. Thus, the older farmer is more likely to accept lower income to avoid the additional risk involved in improving his farm. Swanson (1974) implied that the large proportion of population in the upper age groups in the Whitemud River Watershed in Manitoba is not conducive to efficient use of resources. Whatever income is accumulated is put aside for retirement rather than re-investment. As an area increases in socio-economic complexity, past practices often become antiquated (Napier and Mast, 1981) but are maintained because they have been used over the years. These researchers further suggest that older people perceive land use controls as restricting their behaviour and thus constituting a cost and therefore, they may offer more resistance to imposition of new practices than younger people.

In Western Canada, a significant number of farm operators are in the older age group categories (Tables 7, 8 and 9). In Manitoba, 30.5 percent of farmers are 55 years and over, with 32.16 percent in Saskatchewan and 29.61 percent in Alberta. However, with respect to summerfallow, Macartney (1984) suggested that there is no direct measurable association between age and intensity of summerfallow.

Education -

Denison (1964) postulated that education plays a significant role in productivity regardless of occupation. That is, the more education an individual has the more productive will be his performance. More highly educated people tend to be more favourable toward land use controls since they can perceive the potential impacts and consequences of not controlling the use of land. Also, education is an indicator of the farmer's ability to deal with abstract ideas and should facilitate the operator's capability to determine the feasibility of the alternative solutions being proposed for soil and water problems.

Table 7: Level of Schooling Classified by Age of Farm Operators for Manitoba

Age Groups	University		Other Training	Grade 11-13	Grade 9-10	Grade 7-8	Grade 1-6	No Schooling	Total
	Degree	Some University							
(%)									
Age 15-19 Years ...	-	10	10	75	15	-	-	-	105 (0.35)
Age 20-24 Years ...	30	160	175	555	280	65	5	5	1,290 (4.38)
Age 25-29 Years ...	160	325	470	1,115	460	155	15	5	2,715 (9.22)
Age 30-34 Years ...	245	305	645	945	680	290	115	-	3,225 (10.95)
Age 35-39 Years ...	250	285	465	795	730	535	115	10	3,230 (10.86)
Age 40-44 Years ...	145	220	465	510	700	760	180	15	3,000 (10.02)
Age 45-49 Years ...	145	230	355	370	805	1,085	285	15	3,290 (11.17)
Age 50-54 Years ...	75	155	345	450	850	1,275	460	10	3,615 (12.27)
Age 55-59 Years ...	45	120	185	325	830	1,365	575	35	3,480 (11.81)
Age 60-64 Years ...	35	60	175	270	550	1,165	515	35	2,790 (9.47)
Age 65-69 Years ...	-	50	75	135	220	700	535	50	1,760 (5.97)
Age 70 Years and Over	15	15	20	80	125	420	255	40	975 (3.31)
Total	1,150 (3.90)	1,935 (6.57)	3,390 (11.57)	5,630 (19.12)	6,250 (21.22)	7,825 (26.57)	3,050 (10.35)	210 (0.71)	29,445

Source: Statistics Canada, Unpublished Data, 1981.

Table 8: Level of Schooling Classified by Age of Farm Operators for Saskatchewan

Age Groups	University		Some University	Other Training	Grade 11-13	Grade 9-10	Grade 7-8	Grade 1-6	No Schooling	Total
	Degree									
(%)										
Age 15-19 Years ...	-		35	60	155	90	30	-	-	375 (0.55)
Age 20-24 Years ...	60		335	675	1,535	740	135	-	5	3,480 (5.16)
Age 25-29 Years ...	315		885	1,545	2,430	1,145	350	40	5	7,090 (9.96)
Age 30-34 Years ...	645		1,065	1,665	1,900	1,135	635	50	-	7,090 (10.53)
Age 35-39 Years ...	545		595	1,305	1,550	1,345	1,115	140	5	6,600 (8.80)
Age 40-44 Years ...	270		430	935	1,120	1,690	1,630	180	30	6,285 (9.33)
Age 45-49 Years ...	175		340	1,000	1,095	1,915	2,290	350	50	7,220 (10.72)
Age 50-54 Years ...	180		445	770	1,080	2,180	2,705	450	80	7,895 (11.72)
Age 55-59 Years ...	105		320	530	1,115	2,165	3,120	625	55	8,030 (11.92)
Age 60-64 Years ...	65		340	405	825	1,590	2,595	610	30	6,455 (9.58)
Age 65-69 Years ...	40		105	240	410	690	1,940	590	20	4,040 (6.00)
Age 70 Years and Over	30		115	120	250	435	1,300	755	140	3,135 (4.66)
Total	2,425 (3.60)		5,005 (7.43)	9,240 (13.72)	13,465 (20.00)	15,125 (22.46)	17,835 (26.49)	3,795 (5.63)	420 (0.62)	67,320

Source: Statistics Canada, Unpublished Data, 1981.

Table 9: Level of Schooling Classified by Age of Farm Operators for Alberta

Age Groups	University		Other Training	Grade 11-13	Grade 9-10	Grade 7-8	Grade 1-6	No Schooling	Total
	Degree	Some University							
(%)									
Age 15-19 Years ...	-	-	45	125	35	5	5	-	215 (0.37)
Age 20-24 Years ...	15	130	465	800	325	20	-	5	1,760 (3.03)
Age 25-29 Years ...	215	340	1,490	1,875	340	135	15	5	4,420 (7.61)
Age 30-34 Years ...	665	415	1,955	1,675	930	300	50	5	5,995 (10.32)
Age 35-39 Years ...	580	425	1,925	1,800	1,410	590	105	5	6,835 (11.77)
Age 40-44 Years ...	530	235	1,645	1,470	1,690	1,035	235	20	6,860 (11.81)
Age 45-49 Years ...	325	190	1,490	1,180	2,150	1,575	405	35	7,350 (12.66)
Age 50-54 Years ...	230	170	1,105	1,200	2,095	2,050	490	70	7,420 (12.78)
Age 55-59 Years ...	180	140	935	950	1,875	2,225	540	50	6,895 (11.87)
Age 60-64 Years ...	120	65	545	530	1,255	1,805	405	50	4,775 (8.22)
Age 65-69 Years ...	45	90	370	300	710	1,220	415	30	3,175 (5.46)
Age 70 Years and Over	40	90	210	155	345	880	545	100	2,360 (4.06)
Total	2,950 (5.08)	2,280 (3.92)	12,185 (20.98)	12,060 (20.77)	13,160 (22.66)	11,845 (20.40)	3,200 (5.51)	370 (0.63)	58,055

Source: Statistics Canada, Unpublished Data, 1981.

Swanson (1974) suggested that the lower level of education of farm operators in the Whitemud River Watershed in Manitoba may be responsible for deterioration of the land resource base. This had a direct effect on both the incomes obtained and conservation practices used. Swanson (1974) further noted that older operators with less education will not likely be concerned with conservation practices as it pays off only in the long run. The older operator will also be less able to use information concerning new agricultural practices and likely to adopt to changes in technology. The Council for Agricultural Science and Technology (1981) suggested that farmers on better quality land are also likely to have better education and managerial skills and to participate more actively in local conservation programs and organizations than are farmers on poorer quality land. However, Havens (1965) found no such relationship between education and adoption.

In Manitoba, 58.86 percent of farmers had grade ten or less education, with 55.20 percent in Saskatchewan and 49.20 percent in Alberta (Tables 7, 8 and 9). This indicates that with limited formal training on tillage systems, many Prairie farmers will probably require technical assistance to implement often more complex conservation tillage systems.

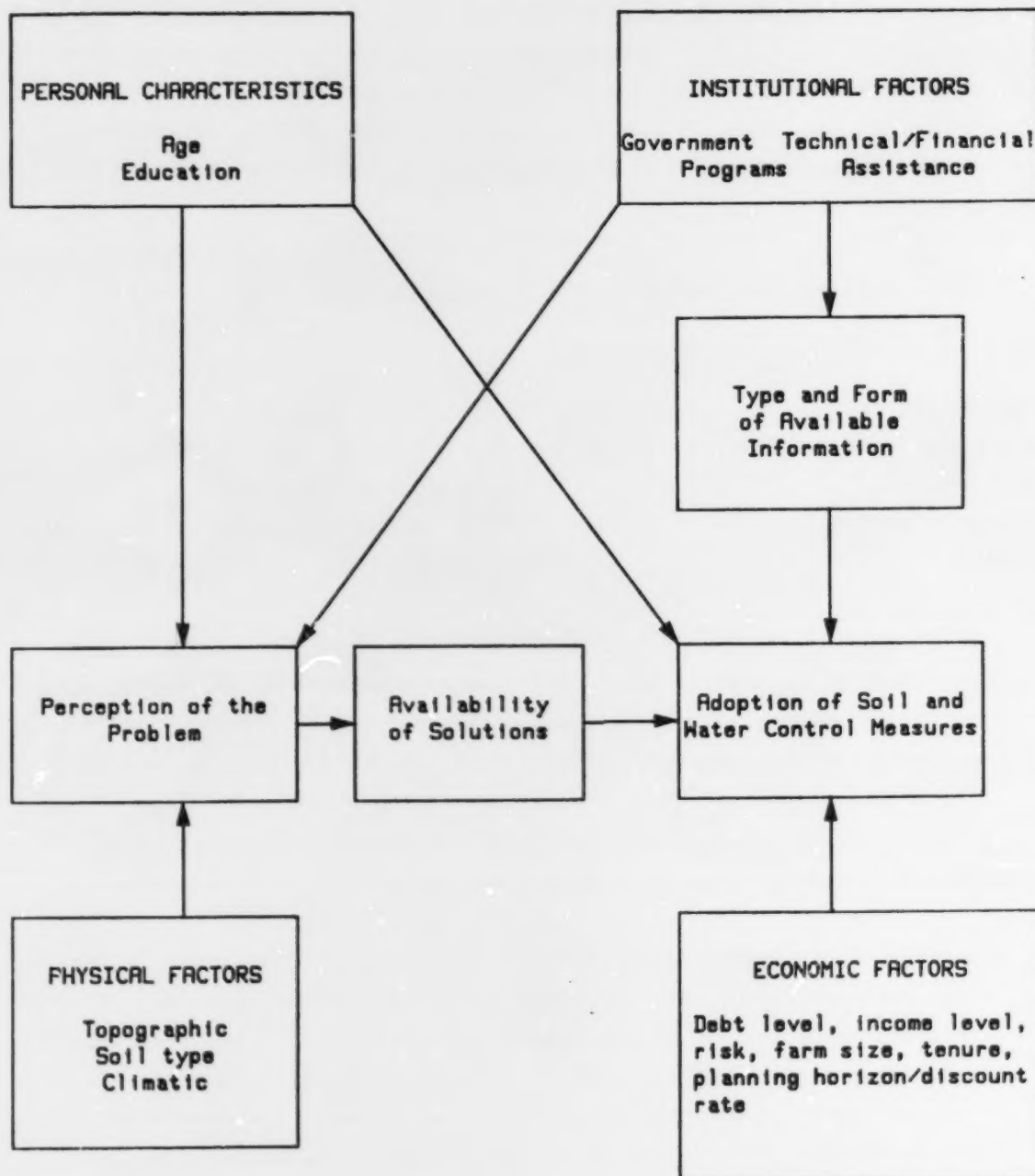
III. ADOPTION PROCESS

Although the factors affecting the adoption and maintenance of water and erosion control measures are addressed separately in Section 2, they do not necessarily influence the adoption of such measures independent of each other. There is an increased realization that the complexity involved with deriving technical solutions to soil and water problems is equally matched by the complexities surrounding the implementation of these technologies. The adoption and use of soil and water conservation practices is conceptualized as the decision-making process, as outlined in Figure 1, with each component visualized as an important step in the decision to control water and soil erosion.

The adoption process may begin by recognition of the erosion problem by the landowner. This recognition depends on the age of the operator, level of education, type and form of available information and institutional factors which enhance the perception of the problem. As illustrated (Figure 1), government programs can serve to increase this perception. However, economic factors, such as debt and income levels may constrain or enhance the implementation of appropriate conservation measures. The adoption may also depend on the availability of suitable solutions. Personal characteristics, such as age and education level can affect the proper application and maintenance of such practices in varying topographic, soil and climatic conditions which in turn determine the erosion potential of the area in question, since a high level of management ability is required to successfully implement water and soil erosion control measures.

Since some conservation practices are costly, in terms of equipment and maintenance, conservation effort is hypothesized to depend heavily on economic factors.

FIGURE 1
A MODEL PORTRAYING HOW VARIOUS FACTORS
INFLUENCE THE ADOPTION OF SOIL AND
WATER CONSERVATION MEASURES



IV. TECHNOLOGY TRANSFER OF SOIL AND WATER CONSERVATION PRACTICES ON THE PRAIRIES

In the Prairies a number of government and non-government organizations are involved in the technology transfer process related to soil and water conservation. These organizations have in recent years undertaken a large number of activities which are aimed at increasing the awareness of soil and water problems as well as increasing the adoption rates of conservation farming practices. This section provides an overview of activities of the major organizations involved in the technology transfer of soil and water conservation practices.

Non-Government Soil and Water Conservation Organizations

Non-government organizations are a significant element of the technology transfer process in many farm communities. In Western Canada there are a number of non-government organizations which are involved in promoting soil and water conservation. The following is a brief description of the non-government soil and water conservation organizations operating in Western Canada.

South Interlake Soil and Water Improvement Association - This organization is a small organization which covers three South Interlake agricultural districts in Manitoba. The goal of the organization is to promote the importance of soil management with demonstration projects. The organization is currently working with the staff of Manitoba Agriculture on planting shelter belts, demonstrations on crop salinity tolerance and crop residues left by various fall tillage practices.

Manitoba-North South Tillage Farmers' Association - This organization is also relatively new, being formally structured in January, 1982. At present, membership is at approximately 200 farmers. The association has undertaken a number of activities to promote no-till. These activities include distributing information on current research and other topics of interest related to no-till or minimum tillage. The association is

also involved in research projects which address some of the technical aspects of no-till. The association has just completed a research project with Versatile Farm Equipment and the University of Manitoba on seed openers and discussions with Monsanto on the economics of burn off chemicals.

Soil Conservation Society of America, Manitoba Chapter - This organization has been basically inactive for the past few years. Unlike the other two soil and water conservation organizations operating in Manitoba, this organization was operated primarily by non-farmers.

Alberta Farmers' Conservation in Crop Production Association - This association is one of the more active associations in Western Canada. This association started back in 1978 with 22 members, and currently has approximately 300 members. Unlike the other conservation organizations, this group receives money from Alberta Agriculture. The major activity of this group is information transfer. The organization publishes a monthly conservation farming newsletter and also coordinates a conservation library. The organization in the past has relied extensively on the Conservation Tillage Information Center in the United States for information. Other activities such as surveying farmers attitudes towards soil conservation and field demonstration have been undertaken by the organization.

Soil Conservation Society of America, Alberta Chapter - This organization is a relatively small organization consisting of about 60 people, of which many are non-farmers. The major activities undertaken by this organization is in the field of education. The organization has directed efforts, not just at the farm community, but at the public at large.

Alberta Dryland Salinity Control Association - This organization was formed in order to prevent additional land in Southern Alberta from degrading due to salinity problems. The organization which was originally just in southern Alberta has become a province-wide organization. One major achievement of this group was a Memorandum of

Understanding which was signed by the Alberta and Montana governments. This agreement provides for the exchange of information on salinity problems between Alberta and Montana. The Dryland Salinity Association has worked closely with the Triangle Conservation Group in Montana in implementing the research of Dr. Paul Brown. The Dryland Salinity Association has in fact distributed 250 copies of Dr. Brown's book in Canada.

Saskatchewan Wheat Pool - The Saskatchewan Wheat Pool has in the past also been active in promoting soil and water conservation. The Saskatchewan Wheat Pool has increased awareness levels by disseminating information to farmers. The Wheat Pool also operates a development farm at Watrous, Saskatchewan, which is involved in information transfer and development of soil and water conservation practices.

Provincial Technology Transfer Activities

Manitoba

The Province of Manitoba has significantly increased its efforts to promote soil and water conservation in the past year. Manitoba Agriculture is working with farmers to demonstrate farming practices that can address the soil degradation problems within Manitoba. In 1984, Manitoba Agriculture will have over 100 field demonstrations through the province, many of which will deal with soil and water conservation. These field demonstrations include comparison of tillage implements, saline soil management and no-till projects. The majority of these projects occur on 2 or 3 ha demonstration plots. Farmers who participate in the program can receive a payment of about \$200. With each demonstration project technical data is collected by Manitoba Agriculture to evaluate the potential of various conservation measures. Manitoba Agriculture also promotes soil and water conservation by disseminating information to farmers. The Soils '84 course, which is a home study course, had some 2000 participants in 1984. This course includes such subjects as salinity, drainage and conservation tillage. Awareness levels of the importance of water and soil conservation are increased by publications such as Land - The Threatened Resource and Soil Stewardship Week.

Manitoba Agriculture has also increased its efforts in the area of extension. Soil management specialists have been assigned to each region in Manitoba. Manitoba Agriculture is also undertaking joint research projects with the University of Manitoba, relating to soil erosion and management. The University of Manitoba has also developed farm budgeting models which can be used by farm operators to determine the economic impacts of changing to production systems which reduce soil erosion.

Saskatchewan

The Saskatchewan Department of Agriculture is also involved in a number of activities to promote soil conservation. The efforts in Saskatchewan, however, are aimed primarily at awareness and education. In the area of extension, Saskatchewan Agriculture holds farmers' meetings and uses press releases to increase farmers' awareness of the need for soil conservation. However, unlike Manitoba which has several soil specialists, Saskatchewan Agriculture has only one soil conservation specialist. Saskatchewan Agriculture also provides publications which increase farmers' knowledge of soil conservation measures.

Saskatchewan Agriculture, through the Farm Lab Program, is also actively involved in promoting soil and water conservation activities. The Farm Lab Program promotes soil conservation by providing funds for demonstration projects and research projects. Under the Farm Lab Program there have been some 250 demonstration projects, of which almost half are related to soil conservation. The Farm Lab Program also promotes soil conservation by providing funds for research under the Innovative Farming Systems Program. Under this program, various aspects of types of production such as no-till and minimal tillage are evaluated at some 30 sites in the province.

Soil conservation farming practices in Saskatchewan are also encouraged under the Soil Drifting Control Act, which is administered by Saskatchewan Agriculture. This Act allows rural municipalities to regulate farming practices within their boundaries in order to reduce soil erosion.

Alberta

Alberta Agriculture has also undertaken a number of activities to increase farmers' awareness of soil erosion. Awareness levels of farmers have been increased by publications and a film on soil and water conservation which has been produced by Alberta Agriculture. Alberta Agriculture has also promoted practices which reduce soil degradation with the Farming for the Future Program. This program consists of a research program, on-farm demonstrations and a graduate student research program. A number of the research programs and on-farm demonstration programs have addressed issues related to soil degradation.

Agriculture Canada's Technology Transfer Activities

Prairie Farm Rehabilitation Administration - The Prairie Farm Rehabilitation Administration (P.F.R.A.) was established in Canada in April 1935 in response to the severe drought situation of the 1930's. In the 1930's and until the mid 1940's, PFRA undertook a number of research projects dealing with farming practices related to soil degradation. However, in the 1940's the work conducted under the Cultural Farm Practices Program was transferred to the Experimental Farm Service. The transfer of the Cultural Farm Practices Program to the Experimental Farm Service would appear to have resulted in reduced emphasis on research related to soil degradation.

In response to the increasing concerns of soil degradation, PFRA undertook a reorganization in 1981. As part of this reorganization, a Soil Conservation Planning Section was established within the Soil and Water Conservation Service. Under the Soil and Water Conservation Service, PFRA has initiated approximately five projects in the Prairies to demonstrate soil conservation farming practices. In 1982-83, PFRA had expenditures of \$594,455 for soil and water technical services (PFRA, 1984).

Research Stations

Although the activities at Research Branch are primarily concerned with research rather than technology transfer, some of the activities of the research stations do contribute to technology transfer. The publication of research results in such publications as Canadex increases farmers awareness of research results related to soil and water conservation. In some instances,

innovative farmers have direct contact with research stations on innovative farming practices. Agricultural research stations also undertake technology transfer with field days and lectures to farm groups concerning soil and water conservation.

The Research Station at Lethbridge has developed farm simulation models which can be used to evaluate technologies related to soil and water conservation. These models can be used to evaluate the economic impacts of such production changes and decreasing summerfallow and changing tillage operations.

Regional Development Branch

Agriculture Canada is also involved in the technology transfer of soil and water conservation measures through the Economic Regional Development Agreements (ERDA). In Saskatchewan the ERDA provides \$10.0M in federal funds and \$4.5M in provincial funds to soil and water conservation and other activities from 1984-85 to 1988-89. This program will be aimed at the development and demonstration of soil and water conservation practices. Soil and water conservation farming practices will also be promoted in Manitoba with the Canada/Manitoba Economic Regional Development Agreement (ERDA). The agreement provides \$8.5M of federal funds and \$8.2M in provincial funds for agricultural development from 1984-85 to 1988-89.

V. TECHNOLOGY TRANSFER OF SOIL AND WATER CONSERVATION PRACTICES IN THE UNITED STATES

This section outlines the major participants involved in the technology transfer of soil and water conservation measures in the United States. As was the case in the Canadian Prairies, soil conservation activities in the United States developed in the 1930's in response to severe economic conditions. However, the methods of transferring technologies related to soil and water have developed substantially differently in the two countries as a result of constitutional and other differences.

Government Organizations

Soil Conservation Districts

Soil Conservation Districts are an integral part of increasing the adoption rates of soil and water conservation measures in the United States. Currently there are some 3,000 conservation Districts in the United States. These districts cover virtually all of the land in the United States. The Districts operate as sub-units of state governments and are empowered to set priorities for conservation work and to coordinate Federal, State and local resources. The conservation districts are governed by locally elected or appointed citizens.

The major activities of Conservation Districts are to study soil conservation problems, develop conservation plans and to provide financial assistance to farmers who adopt soil and water conservation practices. In addition, a number of Conservation Districts also have regulatory powers to regulate conservation practices.

One of the major methods of technology transfer for Conservation Districts is the use of demonstration projects. Demonstration projects usually involve the staff of Conservation Districts working with a number of other government and non-government organizations.

In order to initiate a demonstration project a Conservation District will generally hold a meeting for farmers who may be interested in participating in a demonstration project. The Cooperative Extension Service (CES) and the Soil Conservation Service (SCS) will play a key role in the demonstration project by providing technical assistance to the participating farmers. Training sessions for participating farmers will generally include a discussion on such factors as fertilizer management, planting dates, weed and insect control, seed selection, and spraying techniques. After the initial meeting, the Conservation District determines how many farmers will participate in the project.

In addition to the SCS, technical advice is also provided by the farm input industries. Equipment dealers usually loan or rent conservation tillage equipment to the Conservation Districts for use in demonstration projects. Chemical, seed and fertilizer dealers also provide information to participating farmers.

By participating in the demonstration projects, farmers agree to allow the Conservation District to hold field days and tours during the growing season. In addition to field days and tours, the results of the demonstration plots are distributed in the news media as well as directly to farmers. Conservation Districts also promote soil conservation with awareness programs and information dissemination activities.

Soil Conservation Service

The Conservation Operations Program of the U.S.D.A. provides funding for the Soil Conservation Service (SCS). The Soil Conservation Service was established in the mid 1930's to provide technical advice to farmers who want to adopt soil and water conservation measures. Staff members of the Soil Conservation Service work in close cooperation with the Conservation Districts and farmers by providing technical advice on soil and water conservation practices.

Agricultural Conservation Program

The Agricultural Conservation Program which is administered by the Agricultural Stabilization and Conservation Service also plays a key role in increasing the adoption rates of soil and water conservation measures in the

United States. With this program the federal government in the United States subsidizes those eligible farmers who adopt soil and water conservation measures. The eligibility criteria for selection of conservation measures are determined by local agricultural stabilization and conservation committees which are elected by farmers.

The Agricultural Stabilization and Conservation Service provides funding on either a long-term or annual basis to participating farmers. In 1983, \$184.98 million were spent on this program by the USDA which averaged \$821 per participating farm (USDA, 1983).

Cooperative Extension Service

The Cooperative Extension Service (CES) also plays a major role in promoting soil and water conservation activities in the United States. The mandate of the Cooperative Extension service is to provide education while the SCS provides technical assistance. As a major activity, the CES is involved in transferring the results of soil and water conservation research developed at land grant universities and the Agricultural Research Service to farmers.

Great Plains Conservation Program

The Great Plains Conservation Program (GPCP) was established in the 1950's and provides funding in ten States in the Great Plains. Under this program, a farmer signs a contract with the USDA agreeing to implement conservation practices over a 3 to 10 year time period. When the Conservation programs are implemented, the farmer receives 50 to 80 percent of the cost of implementing soil and water conservation measures up to a cost of \$35,000 (USDA, 1982). In 1981, the U.S.D.A. spent \$15.75 million on this program (USDA, 1983).

Land Grant Universities

Although the universities are primarily concerned with research rather than technology transfer, many land grant universities devote

considerable resources to technology transfer. Staff members often work in close cooperation with the SCS in providing technical assistance to farmers. Research results are also transferred to farmers by publications and extension activities which are often a major component of the university staffs' activities.

Land grant universities have also developed a number of analytical tools which can be used for soil conservation technology transfer. One such analytical tool is the coordinated Farm and Research Management System (COFARM) which was developed at the University of Minnesota. The COFARM assists in farm management decision-making by computer based methods which account for such factors as soil erosion, crop residues, tillage, fertilizer needs and crop yields. Another model which has been developed at the University of Illinois is aimed at improving the efficiency of soil conservation incentive programs. This model quantifies the payments society would pay farmers for achieving soil conservation. This model will allow funds to be targetted to those farmers who are the most adversely affected by adopting conservation practices.

Agricultural Research Service

In addition to land grant universities, the Agriculture Research Service (ARS) of the USDA does extensive research on soil and water conservation practices. This research is carried out on several research farms which are operated by the ARS. The research results are primarily transferred to farmers by the personnel employed by the SCS.

Non-Government Organizations

National Association of Conservation Districts

The National Association of Conservation Districts (NACD) is a non-government organization which consists of local conservation districts. The major goal of the NACD is to increase the awareness amongst the public, farmers and politicians of the need to conserve soil and water resources. The NACD increases awareness by a weekly newsletter to individuals and districts, special reports and by regional and national meetings. The NACD also

increases awareness levels through the Soil Stewardship Week, which has been held with the Conservation Districts since 1955. The NACD also has a number of committees such as an Information and Communications Committee which analyses the NACD and Conservation District activities.

Conservation Tillage Information Center

The Conservation Tillage Information Center is a cooperative effort among the agricultural industry, government agencies, private foundations and farmers. The Center's major responsibility is to act as a clearinghouse for information related to soil and water conservation activities. Information is distributed to farmers and other interested organizations by means of a monthly newsletter, literature searches, speakers bureaux and providing referrals to farmers of university, USDA and agricultural industry specialists who can address specific questions and problems.

The Center has also undertaken in the past two years a number of other activities to promote soil and water conservation. In 1982 and 1983, in cooperation with the Conservation Districts, the Center undertook a survey of adoption rates for various soil and water conservation measures. The Center has also undertaken a survey with the Conservation Districts for reasons of adoption or non-adoption of soil and water conservation practices.

Soil Conservation Society of America

The Soil Conservation Society of America is another non-government organization which is involved in promoting soil and water conservation measures. The SCSA consists of approximately 150 local chapters which undertake a variety of activities to promote soil and water conservation practices. Activities of local chapters include publications for mass distribution, technical papers and technical assistance.

At the national level the SCSA publishes The Journal of Soil and Water Conservation which is distributed to members six times per year. The Society also undertakes an annual meeting which addresses specific issues dealing with soil and water conservation. Other activities, include publishing general information which are aimed at increasing public awareness of the need for soil and water conservation.

VI. ADOPTION RATES OF SOIL AND WATER CONSERVATION PRACTICES

This section outlines the available information on the adoption rates for soil and water conservation practices in Western Canada and the United States. In Western Canada the available information on adoption rates is very limited for most conservation practices. However, in the United States the Conservation Information Tillage Center has collected detailed information on the adoption rates of various conservation measures in the United States.

Adoption Rates on the Prairies

A major factor for the land degradation problems in the Prairies is the large quantity of lands in summerfallow. A reduction in the quantity of land in summerfallow in Western Canada would significantly reduce soil erosion, nitrogen losses and salinity problems. In the past few years the amount of land in summerfallow has decreased significantly. In 1981, there were 9.51 million hectares of summerfallow compared to 10.75 million hectares in 1976.

Although the amount of land in summerfallow has been reduced substantially in recent years, significant regional differences exist in summerfallow trends. In the black and grey wooded soil zones, very significant decreases have occurred in all three Prairie provinces (Table 10). In these soil zones the amount of summerfallow decreased by 1.1 million hectares from 1976 to 1981. This decrease reflects the fact that many farm operators in this soil zone have been able to increase net farm income by eliminating summerfallow (Culver, 1984). This trend is likely to continue particularly if the demand and price for canola remains strong.

In the dark brown soil zone the quantity of land in summerfallow has also decreased in recent years although the decrease in this soil zone has been less significant than in other soil zones. The largest decrease in this soil zone has occurred in Alberta where the quantity of summerfallow decreased from 36 to 29 percent of the cultivated land (Table 11).

Table 10: Summerfallow Area by Province and Soil Zone,
Prairies, 1976 and 1981

Province and Zone	1976	1981	Percentage Change
- million hectares -			%
<u>Manitoba</u>			
Black and Grey	0.93	0.60	-36
<u>Saskatchewan</u>			
Brown	1.98	1.99	+1
Dark Brown	2.54	2.46	-3
Black	2.66	2.24	-16
<u>Alberta</u>			
Brown	0.66	0.68	+3
Dark Brown	0.62	0.52	-16
Black and Grey	1.33	0.99	-26
<u>Prairie Provinces</u>			
Brown	2.65	2.68	+1
Dark Brown	3.15	2.99	-5
Black and Gray	4.94	3.83	-22
<u>Total Prairies</u>	10.75	9.51	-11

Source: Statistics Canada, Agriculture Census Division, Crops Section, 1984

Table 11: Percentage of Cultivated Area in Summerfallow
and Soil Zone, 1976 and 1981

Province and Soil Zone	Year	
	1976	1981
percent		
<u>Manitoba</u>		
Black and Grey	22.2	13.3
<u>Saskatchewan</u>		
Brown	46.8	45.6
Dark Brown	43.8	41.3
Black and Grey	38.7	30.3
<u>Alberta</u>		
Brown	40.6	38.4
Dark Brown	36.2	29.3
Black and Grey	25.1	17.6

Source: Statistics Canada, Agriculture Census Division, Crops Section, 1984

In the brown soil zone, the quantities of land in summerfallow did not decrease from 1976 to 1981. In this soil zone, summerfallow land accounted for 46 and 38 percent of the cultivated land in Saskatchewan and Alberta respectively in 1981 (Table 11). With the limited rainfall in this region, farm operators in general do not benefit by reducing summerfallow.

The incorporation of a legume into a rotation can also significantly improve soil structure by adding organic matter and reduce wind and water erosion and significantly reduce the need for nitrogen fertilizers. In a recent analysis (Culver 1984) of long-term rotations (1958-1980) at Indian Head, Saskatchewan, the three-year rotation incorporating a legume compared favourably in terms of net farm income with other rotations given 1982 input prices and wheat prices. Despite the potential of rotations incorporating a legume in the dark brown and black soil zones, the percentage of farmers which have incorporated a legume in rotation is very small (Table 12). In the brown soil zone, the use of legumes in rotations on dryland farms is not a viable option due to moisture limitation.

The increased adoption of conservation tillage practices on the Prairies could also significantly improve soil and water resources. The number of farmers however in Western Canada who have adopted conservation tillage practices is quite small. The adoption of no-till which represents the most dramatic change from conventional tillage practices is very low. In Manitoba, it is estimated that approximately 7,700 hectares were no-tilled in 1983 (Issue No. 6, Senate Committee Hearing). This figure has remained relatively unchanged in the past three years. In Alberta, approximately 35 to 40 farmers are practicing no-till (Issue No. 8, Senate Committee Hearings).

In addition to no-till, other conservation tillage practices include reduced till and mulch till on stubble or summerfallow. In the period from 1978 to 1981 in which Prairie grain farmers experienced significantly higher energy prices the vast majority of farmers did not reduce tillage operations on stubble or summerfallow (Table 13). This may indicate that most farmers did not believe potential fuel saving with reduced tillage would justify the perceived yield decreases with no-till.

Table 12: Percent of Prairie Grain and Oilseed Farm With Cover Crop/Green Manure Plowed Down by Soil Zone and Province, 1982

	Cover Crop/Green Manure Grown and Plowed Down	No Cover Crop/ Green Manure Grown and Plowed Down	No Response
- percent -			
<u>Manitoba</u>			
Black	1.0	97.6	1.4
Grey Wooded	3.0	95.2	1.9
<u>Saskatchewan</u>			
Brown	0.0	97.0	3.0
Dark Brown	1.9	97.7	0.4
Black	1.3	98.3	0.3
<u>Alberta</u>			
Brown	5.0	89.7	5.3
Dark Brown	0.0	94.8	5.2
Grey Wooded	2.3	89.2	8.5
Black	1.7	96.5	1.8

Source: Farm Energy Use Survey 1982, Special Tabulation Produced by
Statistics Canada

Table 13: Trends in Number of Tillage Operations on Prairie Grain Farms,
1978-1981

	Manitoba	Saskatchewan	Alberta
<u>Number of Tillage Operations in a Year on Grain Crops</u>			
Increased since 1978	1,164	4,757	1,954
Decreased since 1978	1,284	2,836	2,172
No change since 1978	16,919	47,353	31,989
No response	4,848	5,959	10,117
<u>Number of Tillage Operations in a Year on Summerfallow</u>			
Increased since 1978	441	980	1,177
Decreased since 1978	1,509	2,133	1,753
No change since 1978	17,785	51,723	32,592
No response	5,165	6,070	10,710

Source: Farm Energy Use Survey, Statistics Canada, 1982.

The reduction of tillage operations on summerfallow and crop land can also contribute to the alleviation of soil degradation problems in western Canada. Excessive tillage operations for weed control on soil preparation can cause soil erosion and a break down of the soil structure. The results from the Farm Energy Use Survey, however, indicate that excessive tillage operations are carried out by many farm operators.

A large number of grain producers on the prairies are performing four or five tillage operations on crop land (Table 14). In Manitoba, 37 percent of grain farmers are performing five tillage operations on crop land. Reduced tillage operations (one or two tillage operations) were practiced by only 18 percent of Manitoba farmers in 1982. In the grey wooded soil zone in Manitoba, ten percent of farmers had one or two tillage operations in 1982 compared to three percent in the black soil zone. In Saskatchewan, 34 percent of grain farmers had four or five tillage operations on crop land. In the brown soil zone, 57 percent of farmers had one or two tillage operations on crop land in 1982. One or two tillage operations on crop land were practiced by 33 and 18 percent respectively of the farmers in the dark brown and black soil zone in Saskatchewan. In Alberta, the majority of farmers in the black and grey wooded soil zones performed four or five tillage operations on crop land in 1982.

In addition to excessive tillage operations on crop land, many grain producers would appear to practice excess tillage on summerfallow land (Table 15). In Manitoba, 69 percent of the grain farms had five tillage operations on summerfallow land. In both the black and grey wooded soil zones in Manitoba the majority of the producers had five tillage operations on summerfallow land. In Saskatchewan, 68 percent of prairie grain farmers had five tillage operations on summerfallow in 1982. The dark brown and black soil zone had a higher number of tillage operations than in the brown soil zone in Saskatchewan. As illustrated in Table 15, Alberta illustrated similar trends as Manitoba and Saskatchewan.

Table 14: Number of Tillage Operations Per Year on Grain Crop,
by Soil Zones, 1982

	Number of Tillage Operations					No
	1	2	3	4	5	Answer
- number of farms -						
<u>Manitoba</u>						
All Soil Zones	842	2,776	4,052	4,366	7,085	5,094
Black	490	1,972	3,331	3,653	6,426	2,927
Grey Wooded	352	804	721	713	659	2,167
<u>Saskatchewan</u>						
All Soil Zones	4,731	12,756	18,991	8,926	9,593	5,906
Brown	2,027	5,023	4,194	777	294	1,280
Dark Brown	1,389	4,123	6,585	2,554	2,018	1,436
Black	1,315	3,610	8,212	5,595	7,281	3,190
<u>Alberta</u>						
All Soil Zones	1,524	5,812	10,010	8,521	10,317	10,044
Brown	805	1,622	914	401	682	1,620
Dark Brown	251	768	1,519	1,113	824	1,037
Black	193	2,154	3,567	4,159	4,813	3,691
Grey Wooded	275	1,268	4,010	2,848	3,998	3,696

Source: Farm Energy Use Survey 1982 Special Tabulation
Produced by Statistics Canada

Table 15: Number of Tillage Operations Per Year on Summerfallow,
by Soil Zones, 1982

	Number of Tillage Operations					No
	1	2	3	4	5	Answer

- number of farms -						
<u>Manitoba</u>						
All Soil Zones	499	491	568	2,832	10,187	9,639
Black	381	303	525	2,368	8,110	7,112
Grey Wooded	118	188	43	464	2,077	2,527
<u>Saskatchewan</u>						
All Soil Zones	*	347	3,441	13,052	37,280	6,785
Brown	*	284	1,633	5,956	4,219	1,505
Dark Brown	*	*	1,466	5,267	9,788	1,582
Black	*	61	342	1,829	23,273	3,699
<u>Alberta</u>						
All Soil Zones	1,033	1,168	3,581	6,319	16,377	17,752
Brown	155	83	809	1,137	1,190	2,672
Dark Brown	34	196	416	1,425	1,651	1,788
Black	289	138	782	1,838	8,286	7,246
Grey Wooded	555	751	1,574	1,919	5,250	6,046

* Indicates less than five farms.

Source: Farm Energy Use Survey 1982 Special Tabulation
Produced by Statistics Canada

Adoption Rates in the United States

In the United States, the Conservation Tillage Information Center provides information on the trends and extent of conservation tillage. The number of farms using conservation tillage has increased significantly in recent years. On a national basis, the number of farmers using conservation tillage increased by 250 percent (Table 16). In the Northern Plains, 184 farmers per conservation district used conservation tillage in 1982 which was a 170 percent increase from 1977.

Detailed information on the extent of conservation tillage practices has been collected on an annual basis since 1982 in the United States by a national survey of Conservation Districts. This survey is coordinated by the CTIC with the SCS taking the lead role in completing the survey in each county. In each district the SCS District Conservationist completed the survey with help from other government agencies and the local farm input industries.

The survey collected information of five conservation tillage systems, no-till or slot planting, ridge-till, strip-till, mulch-till, and reduced till by crop type. To ensure consistency in the survey, each tillage system was defined as outlined in Appendix I.

The 1983 Survey indicated that conservation tillage was applied to 31 percent of the cropland in the United States (Table 17). The most popular form of conservation tillage was mulch tillage followed by reduced tillage. No-till was applied to 3.6 percent of the cropland which represents 4.08 million hectares. Ridge-till and strip-till was applied to less than one percent of the cropland in the United States. No-till was applied to 1.4 percent of the area planted in small grains in 1983. On full season corn, no-till practices were used on 1.36 million hectares, which represents 5.9 percent of the total full season corn area planted.

Table 16: Adoption Rates of Conservation Tillage Practices
in the United States, by Region, 1977-1982

1977	Percentage Change 1977 to 1982	Average Number of Farmers per District	
		1977	1982
National*	250	67	165
Northeast	300	18	54
Appalachian	200	50	100
Southeast	270	15	40
Lake	340	53	179
Corn Belt	270	110	293
Delta	400	15	60
No. Plains	170	111	184
So. Plains	140	60	87
Mountain	310	12	37
Pacific	170	31	54

* These are an average of all districts, not of regions.

Source: Conservation Tillage Information Centre, January 1984 Local Action
and Views

Table 17: Percentage of Selected Crops Under Various Conservation Tillage Practices, United States, 1983

Category	No-till	Ridge-till	Strip-till	Mulch-till	Red. Till	Cons. Till*
	percent					
Corn (FS)	5.92	1.02	0.51	25.24	7.03	39.73
Corn (DC)	28.18	0.13	0.13	12.05	13.48	53.97
Small Grain	1.43	0.10	0.15	19.06	13.13	33.88
Soybeans (FS)	1.76	0.51	0.14	21.26	5.73	29.40
Soybeans (DC)	33.01	0.19	0.57	14.29	10.54	58.59
Cotton	0.19	0.54	0.05	2.50	2.51	5.80
Grain Sorghum (FS)	3.07	0.50	0.26	18.80	13.89	36.53
Grain Sorghum (DC)	18.55	0.46	0.91	17.25	14.75	51.92
Veg. & Truck Crops	0.28	0.12	0.07	2.40	2.70	5.57
Forage Crops	1.87	0.13	0.08	6.01	6.74	14.83
- Permanent Pasture	4.73	0.01	0.04	4.54	5.52	14.85
Other Crops	1.15	0.06	0.06	5.44	5.06	11.76
- Fallow	4.79	--	--	15.71	10.23	30.74
- Conservation Use	--	--	--	--	--	--
Totals	3.63	0.41	0.23	18.11	8.89	31.28

* Sum of No-Till, Ridge-Till, Strip Till, Mulch Till, Reduced Till

-- No Acres Reported.

FS = Full Season

DC = Double Crop

Fallow includes cropland idled for the entire year.

Conservation use includes cropland idled for pik, set aside, or diverted acres.

Source: Conservation Tillage Information Centre, 1983. National Survey Conservation Tillage Practices, 1984.

In the North Plains region of the United States, conservation tillage was applied to 38 percent of the cropland in 1983 (Table 18). Mulch till and reduced tillage systems were the two most popular forms of conservation tillage. No-till was applied to 458,000 hectares which represents 1.9 percent of the cropland. In North Dakota, no-till was applied to about 67,800 hectares compared to less than 10,000 hectares in Manitoba. Conservation tillage practices were used on 16.7 percent of the cropland in North Dakota which is considerably less than the 31 percent on a national basis.

Table 18: Percentages of Selected Crops Under Various Conservation Tillage Practices,
Northern Plains, 1983

Category	No-till	Ridge-till	Strip-till	Mulch-till	Red. Till	Cons. Till*
	percent					
Corn (FS)	2.73	2.02	1.77	26.37	15.32	48.22
Corn (DC)	36.89	--		13.31	5.17	55.36
Small Grain	1.19	0.03	0.40	20.29	17.82	39.73
Soybeans (FS)	1.49	0.48	0.33	19.90	12.80	35.00
Soybeans (DC)	20.44	0.14	0.34	24.57	23.67	69.15
Cotton	--	--	--	--	--	--
Grain Sorghum (FS)	5.58	0.80	0.47	29.49	20.50	56.85
Grain Sorghum (DC)	19.91	1.22	0.16	31.08	21.79	74.16
Veg. & Truck Crops	--		0.26	0.61	0.10	0.97
Forage Crops	0.42	--	0.05	4.48	7.47	12.42
- Permanent Pasture	0.23	--	--	2.11	1.86	4.20
Other Crops	0.39	0.13	0.04	7.45	4.41	12.41
- Fallow	8.63	--	--	22.12	17.43	48.18
- Conservation Use	--	--	--	--	--	--
Totals	1.89	0.45	0.56	19.76	15.48	38.13

* Sum of No Till, Ridge Till, Strip Till, Mulch Till, Reduced Till

-- No Acres Reported.

FS = Full Season

DC = Double Crop

Fallow includes cropland idled for the entire year.

Conservation use includes cropland idled for pik, set aside, or diverted acres.

Source: Conservation Tillage Information Centre, 1983. National Survey Conservation Tillage Practices, 1984.

VII. A PRELIMINARY OVERVIEW OF POSSIBLE GOVERNMENT INITIATIVES TO ENHANCE THE RATES OF ADOPTION OF CONSERVATION PRACTICES

The need for government involvement in soil and water activities is generally accepted by both farmers and non-farmers, without government involvement the private and public cost of soil degradation will remain at unacceptable high levels. Recent experience has indicated that soil erosion problems in Western Canada will continue with an unacceptably high level of social and private costs. In Western Canada, social costs will include reduced opportunities for the expansion of grain production and related economic activities. In the United States, a Harris Poll in 1979 found Americans supported federal actions to protect farmland from erosion by a seven to one margin (Korsching, 1983). A survey of farmers in Iowa in 1980, however, determined that only certain types of government actions are acceptable to farmers. Economic incentives and educational programs on soil conservation were acceptable to 64 and 74 percent of farmers surveyed respectively (Korsching, 1983). Only 28 percent of the farmers surveyed indicated economic penalties were acceptable and 24 percent viewed legal regulations as an acceptable method of controlling soil erosion. Although comparable figures are not available for Western Canada, this information indicates that government initiatives which do not promote conservation on a voluntary basis may encounter a large degree of resistance and have only limited success.

This section outlines a number of government instruments which could be considered by Agriculture Canada as approaches to increasing the adoption rates of soil conservation technologies. The selected program instruments are evaluated against a number of criteria such as cost, impact on adoption rates and complexity. The evaluation provides a relative ranking (low, medium, high) of the various program instruments (Table 19). These rankings are preliminary and judgemental and depend on actual program developments. In addition to the criteria discussed in this section, program initiatives must also account for the socio-economic characteristics as outlined in Section II.

Capital Grants for Conservation Equipment

As previously discussed, conservation tillage practices have been shown to be profitable for many farmers in the United States. However, the capital cost of conservation tillage equipment can significantly reduce the

Table 19: A Preliminary Overview of Possible Soil Conservation Program Instruments for Western Canada

Program Instruments	Equity	Need for Federal-Provincial Cooperation	Impacts on Current Adoption Rates	Impacts on Future Adoption Rates	Aggregate Cost	Complexity to Administer	Difficulty in Targetting
Capital Grants for Conservation Equipment	Low	Low	Low-Medium	Low-Medium	Low-High	Low	Medium-High
Technical Assistance	High	High	High	High	Low-High	Low	Low
Demonstrations	Medium	High	Medium	Medium	Medium	Medium	Medium
Cost Sharing	Low-Medium	Low	Low-High	Low-High	Low-High	Medium-High	Low
Indirect Tax Changes	Low	Medium	Medium	Medium	Medium-High	High	High
Increased Information Dissemination	High	Medium	Medium-High	Medium-High	Low	Low	Low
Research	High	Low	Low	High	Medium	Low	Low
Cross Compliance	Low-Medium	High	Low-High	Low-High	Low	High	Medium
Income Tax Changes	Low	Low	Low-Medium	Low-Medium	Low	Low	High
Financial Assistance to Non-Government Organizations	Medium	Low	Medium	Medium	Low	Low	Low
Establish Conservation Districts	Medium	High	Low-High	Low-High	Low	Low	Low
Crop Insurance	High	High	Medium	Medium	Medium	High	Low

economic benefits of conservation tillage. One method to reduce the costs of conservation tillage equipment is to provide capital grants (Table 19). Capital grants would probably have a low to medium impact on the adoption rates. Depending on the size of the grant, the cost of such a program will vary considerably; although if the grant is to have an impact, it must cover a significant proportion of costs. One major problem with this program instrument is equity problems may occur, for example, when a farmer reduces summerfallow or undertakes other conservation practices which do not involve equipment purchases. Capital grants on conservation equipment may also be difficult to target since machinery can be moved amongst farmers.

Technical Assistance

Due to the complexity of many soil conservation practices, technical assistance is often critical if the adoption of soil conservation technologies is to be successful. Such assistance may include the selection and adjustment of appropriate conservation tillage equipment and recommendations concerning herbicide and fertilizer usage. A program aimed at increasing technical assistance will require significant support from provincial extension activities. Technical assistance should have a large impact on the short-run and long-run adoption rates of soil conservation technologies. This type of program could be easily targetted and would be relatively easy to administer. If technical assistance could be provided within the existing government structure (Prairie Farm Administration Act or Extension Services) the cost will be relatively low.

Demonstrations

Demonstration of soil conservation technologies has been a major element of conservation programs developed by Conservation Districts in the United States. Since many conservation technologies are site specific, farm demonstrations will have to occur on many different locations. Farm demonstrations should have a medium impact on adoption rates. The cost of farm demonstration programs could be significant if a large number are undertaken. Some problems could be anticipated in the equity of farm demonstration in that tillage practices under some farm conditions may not be demonstrated. Farm demonstrations of tillage practices could be relatively easily targeted to regions with the most severe erosion problems. To be successful, farm demonstrations may require significant cooperation from provincial extension organizations.

Cost Sharing

Cost sharing programs involve a payment to farmers for land which is under conservation tillage. In the United States a farmer usually receives a payment of \$25.00/hectare. This payment usually covers only the additional costs for renting conservation equipment. The impacts on adoption rates of cost sharing programs will vary depending on the level of funding. Cost sharing programs are relatively difficult to administer since personal visits are required to farms to ensure compliance with the program. Also, cost sharing may not be equitable since in some instances conservation tillage may increase farm returns while other farmers may have a significant decrease in income levels. An advantage of cost sharing is that it could be easily targetted to specific regions.

Increased Information Dissemination

A program which enhanced the dissemination of technical and economic data would assist farmers in evaluating various conservation practices. Increased information dissemination could have a significant impact on adoption rates at a relatively low cost. In the United States, the Conservation Information Tillage Center has significantly increased information dissemination with a modest budget and staff. The complexity in administering such a program will be low, although targetting such a program will also be difficult.

Indirect Tax Changes

Programs which change the taxes on farm inputs could also impact on the adoption rates of soil conservation practices. A reduction of federal taxes on feedstocks for nitrogen fertilizers could improve the economic viability of continuous cropping if tax reduction resulted in lower nitrogen prices. Conversely, the removal of the federal sales tax on liquid fuels would reduce the economic benefits of conservation tillage. Indirect tax changes however, could be difficult to administer and to target. Such tax changes may also not be very equitable to other sectors of society. The impacts on adoption rates would depend on the extent to which the tax changes increase or decrease the profitability of conservation tillage practices.

Increase Research

Research activities into conservation farming systems are of critical importance in the adoption process. Increased research activities however, would have a relatively low impact on adoption rates in the immediate-term. In the longer run, however, increased research activities should result in improved conservation technologies and increases in adoption rates. Increased research would not be difficult to administer and could be targetted to those regions of greatest need. Increased research would also be equitable to all members in the farming community.

Cross Compliance

Cross compliance would ensure that those farmers who receive federal government money undertake conservation measures. In Western Canada, funds provided under the Western Grain Stabilization Act and the Crop Insurance Program could be used to ensure cross compliance. To ensure the success of such a program, a high degree of provincial cooperation will be required. The impacts on adoption rates would be highly dependent on the extent to which funds are withheld under cross compliance. Cross compliance would be complex to administer since the farming practices on each farm would have to be verified for compliance. The cost of such a program will be low and, in fact, cross compliance may even reduce government expenditures. Since the extent of land degradation could be difficult to determine, equity questions could arise with such programs.

Income Tax Changes

Changes in the income tax system, such as faster depreciation charges for conservation equipment, is another program approach which could impact on the adoption rates of conservation technologies. Such changes however would have a relatively low impact on adoption rates since the benefits to most farmers would be relatively small. Changes in the income tax system would be relatively difficult to target and equity problems may arise in that some farmers may not benefit from such changes. The cost and complexity to administer such programs will be relatively low.

Financial Assistance to Non-Government Organizations

As previously discussed, several non-government groups are actively promoting soil conservation in the Prairies. With increased financial resources, many of these groups could expand activities and increase adoption rates of soil and water technologies. The cost of such a program would be relatively low. This type of program would also be easy to target and also to administer. Equity questions could perhaps arise since conservation organizations are only active in selected regions.

Establish Conservation Districts

The establishment of more conservation districts could also impact on the adoption rates of soil conservation practices. Such programs would require a high degree of cooperation between federal and provincial governments. The impacts of conservation districts on adoption rates would be highly dependent on the technical and financial resources of the conservation districts. The actual cost of establishing conservation districts will be relatively low, however, considerable costs could occur in providing technical and financial support. The establishment of conservation districts would be relatively easy to target to those regions with the most severe erosion problems.

Crop Insurance

Changes to crop insurance payments could also be used to promote soil conservation. These changes could involve providing additional insurance for farmers practising soil conservation and equalizing payments for stubble and summerfallow crops. These changes are expected to have a medium impact on adoption rates in soil conservation practices. The cost of such changes would probably be significant, although as farmers become more familiar with conservation practices, costs would decrease. Such changes however, could be difficult to administer since personal visits would be required to determine the extent of conservation practices. Another difficulty with this program is that a high level of cooperation would be needed by provincial governments. Advantages to programs using crop insurance is that programs could be targetted and would be viewed as equitable.

VIII. DISCUSSION AND CONCLUSION

This review of the factors affecting the adoption and implementation of soil and water conservation measures have indicated conflicting conclusions. This is not surprising since the results of most of the studies took place in different regions and in many cases are the result of different social, cultural and economic factors and are thus consistent with respect to the view that individuals or groups differ in their norms and attitudes (Lassey 1977).¹ As such, blanket recommendations with respect to the adoption of soil and water control measures employed would not be appropriate. Since social attitudes change, so do economic, soil, climatic and topographic conditions. As these situations change, recommendations need to be changed to match physical and social conditions of each identifiable group.²

The assumption that information is diffused uniformly across all farm groups is not a valid one. Farmers have different base levels of knowledge as well as varying capacities to assume new technology. This is supported by evidence that farmers with low education levels tend to be less interested in conservation practices. Further, a recent survey by the Conservation Tillage Information Center revealed that operator's receive the most of their information from other farmers. This process of dissemination can provide negative results since the farmer may relay the wrong information depending on the level of his knowledge. There also appears to be conflicting technologies, that is, many ways to do one thing. For example, there is not one conservation tillage system but numerous, and they are site specific. Thus, farm operators may have a difficult time in understanding the underlying

¹ It could also be argued that conflicting results may be due to different methods of analysis used.

² The accommodation of individuals might not be practical from a planning point of view.

principles of these measures as a basis for deciding which practice to adopt. The complexity of implementation and supervision, including matching the proper tillage system to the proper soil type, is a major factor in the success or failure of soil and water control measures.

Difficulty in changing the attitudes of farm operators is exemplified by the practices of summerfallow. The practice of summerfallow, which intensifies the erosion process, is still carried out in areas of southern Manitoba, specifically Eden Creek Watershed, despite receiving over 16 inches of rainfall annually³ and the efforts of the provincial organizations to eliminate such practices. This watershed is characterized by high levels of erosion, rainstorm run-off with the majority of the farm operators in the higher age group categories (Seecharan, 1980).

However, Macartney (1984) indicated no positive relationship between summerfallow and certain farm and operator characteristics. This, however, does not imply that the same relationship exists for other unspecified conservation practices. Further, it would seem that Macartney's study, which was based on soil-climatic zones, may not have indicated any significant relationship since the approach needed is to specify or identify the erosion prone areas. Such a study can examine the relationship between various socio-economic factors and the adoption of conservation practices and perhaps compare the results with other areas where these problems are not evident.

Government policy also needs to be clearly specified since a particular policy that serves one goal may hinder another. For instance, the recent report by the Environment Council of Alberta (1981) pointed out that incentives for reducing wheat acreage in 1970 increased the fallow acreage. Government policies related to taxes on liquid fuels and petrochemical feedstocks can also affect the adoption rates of soil and water conservation measures.

Additional research is needed to be carried out on the direct and indirect effects of soil conservation measures. Farmers surveyed in the United States have stated that weed control, insect and disease control, residue management and lack of technical assistance are likely to hinder

³ Results have shown that areas received 16 inches of rainfall annually should not be practicing summer fallow, Spratt et al., 1975.

the adoption process. Further, farmers have expressed concern about the residual effects of some herbicides on crops in the rotation and the lack of custom operators or machinery rental arrangement options. (Defiance County Soil and Water Conservation District, 1983).

Agronomic and economic research in Canada is needed by both the private and public sectors to further develop conservation practices which are suitable for various locations on the Prairies. A particular need exists for conservation practices which are appropriate for the brown soil zone where the quantity of summerfallow has not decreased in recent years. Research is also needed on the indirect impacts on such factors as increases in herbicide usage with no-till.

There is no doubt that economic factors are major forces behind the adoption of water and erosion control measures. Studies of soil and water conservation measures should not only examine the physical and technical feasibility but also identify other constraints such as credit, debt capacity and prices so as to identify those constraints under which the adoption of such measures would succeed or fail. The results of a wide variety of empirical studies in the United States, which suggests that farm size is a surrogate for a large number of potentially important factors such as credit, capacity to bear risk and access to inputs (fertilizer, seeds etc) needs to be re-assessed so that operators of small farms can readily gain access to credit and perhaps at a low rate of interest. The rationale for such assistance could be based on the fact that soil will be needed for food and fiber production into the indefinite future. Hence, both public and private actions are needed to bring rates of soil erosion into equilibrium with rates of formation.

It should be emphasized that the level of financial risk is also increased in periods of crop failure due to climate variability. As such, a greater strain is placed on the long-run financial viability of the farm operation. Recent drought problems on the Prairies would perhaps make farmers reluctant to adopt soil enhancing strategies if no assistance is provided in such periods of distress.

It would seem also that the adoption of conservation measures which are scale neutral (eg., residue management and zero-till) induces operators to mobilize the relatively small cash requirements for the necessary inputs. The success of conservation tillage in the United States, (Conservations Tillage Information Centre 1984) which requires less capital investment compared with large investments associated with the installation of terraces support this assertion.

An important factor inhibiting the adoption of soil conservation technologies in Canada appears to be the lack of information transferred between various Canadian government and non-government organizations. As previously discussed, a number of organizations, private and public, have in the past and are currently undertaking development and demonstration projects related to soil and water conservation technologies. In many situations, information is not transferred beyond a selected group of individuals who belong to a soil conservation organization. In response to a similar problem in the United States, the Conservation Information Tillage Center was established to act as a clearing-house for information on conservation tillage.

The level of adoption of conservation farming practices in the Prairies would be likely to increase if more emphasis was placed on identifying and evaluating research undertaken outside of Canada which may be appropriate in Western Canada. However, it is important that the impacts of local conditions such as soil and climate be evaluated. Although a number of individuals are familiar with international research, there is no formal system for identifying and evaluating technologies which could be transferred to farmers in the Prairies. A number of non-government organizations have indicated that they rely heavily on conservation information from the United States. However, without a structured organization identifying and evaluating international technologies, many important technologies may not be adopted in the Prairies for a considerable length of time after adoption in other countries.

The lack of people specializing in soil and water conservation technologies is another problem in the Prairies. With the exception of Manitoba which has increased its soil resource personnel, the number of soil specialists in the Prairies is very limited. Farmers in the Prairies often

must rely on extension personnel for advice, on soil and water conservation measures. These staff often have limited knowledge and experience on complex soil conservation measures. This situation contrasts significantly with the situation in the United States where the SCS provides technical advice on soil conservation measures to farmers.

The lack of financial and human resources within non-governmental soil conservation organizations is also impeding the adoption of conservation measures. Non-government organizations which are operated by farmers can be an important element of technology transfer. However, although these groups are often operated by dedicated farmers, they lack the resources to undertake many worthwhile activities. The expanding and strengthening of these organizations could play an important role in increasing the adoption rates of conservation measures.

A number of farm and operator personal characteristics have been identified (such as older operators, low education levels, etc.) and shown to significantly affect the adoption of soil and water conservation measures in the United States. However, lack of conclusive results, except those by Swanson, (1974), precludes any definite conclusions for Western Canada. As such, it is necessary that empirical Canadian studies be undertaken to identify the type of relationship that exists so that appropriate actions can be taken since the studies in the United States have shown that the adoption behavior differs across socio-economic groups.

The means of achieving desirable levels⁴ of soil and water control in Western Canada have already been identified. However, a number of conditions are essential to the dissemination and adoption of soil and water conservation measures. Those following conditions appear to be important:

1. Technology is best transferred directly from person to person; local people who are expected to use the techniques need to learn directly from those who have experience applying them.
2. The technology needs to be adapted on site to local physical, economic, as well as social conditions.

⁴The level will need to be quantitatively identified.

3. That agents of a technology transfer system must be knowledgeable and well qualified, while the people at the receiving end must be receptive to the change.
4. Most transfers also require a "facilitator" who understands the technology transfer process, including the physical, social, and economic constraints involved.
5. Both users and transfer agents should be involved in choosing the technologies and in planning and implementing the transfer process so that the technology meets the actual needs of the operator.
6. The environment for demonstrations of the control measures should be similar to the environment that will exist for actual users. Pilot transfer projects should not be unrealistically easy or conducted under atypical conditions.
7. The initial commitment of resources to the process should be sufficient to carry the technology transfer until it is self-supporting or the risk is reduced to an acceptable level.
8. The transfer process must include ways for all participants to evaluate the process and suggest improvements.

In conclusion, it is apparent that motivating farmers to adopt water and erosion control practices is a complex and dynamic process which is perhaps complicated by the age and level of the education of the farm operator. There is no doubt that trained personnel are required to recognize the interdisciplinary nature of this problem. Further, some of the issues that influence the operator's decision to adopt conservation practices require further research, especially in Canada. The direction of this research should explore the socio-economic factors affecting the adoption process and integrate the results with agronomic studies that deal with the diversity of soil and climatic conditions. The research should examine the profitability of various conservation practices in terms of annual income, debt-equity relationships, taxes, and land control through various tenure arrangements.

Such studies would help provide farmers with the necessary information to make a rational decision and would perhaps provide the basis for the appropriate level of subsidy needed under various physical conditions.

The interdisciplinary nature of this research also requires a high degree of coordination between the organizations and individuals involved in the different aspects of soil and water research. This coordination is essential to ensure that Western Canadian farmers receive the best available economic and technical data on farming practices which address soil and water problems.

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APPENDIX I

DEFINITIONS OF CONSERVATION TILLAGE SYSTEM

Types of Conservation Tillage

1. No-till or slot planting

The soil is left undisturbed prior to planting. Planting is completed in a narrow seedbed approximately 1-3 inches wide. Weed control is accomplished primarily with herbicides.

2. Ridge till (includes no-till on ridge)

The soil is left undisturbed prior to planting. Approximately 1/3 of the soil surface is tilled at planting with sweeps or row cleaners. Planting is completed on ridges usually 4-6 inches higher than the row middles. Weed control is accomplished with a combination of herbicides and cultivation. Cultivation is used to rebuild ridges.

3. Strip till

The soil is left undisturbed prior to planting. Approximately 1/3 of the soil surface is tilled at planting time. Tillage in the row may consist of a rototiller, in-row chisel, row cleaners, etc. Weed control is accomplished with a combination of herbicides and cultivation.

4. Mulch till

The total soil surface is disturbed by tillage prior to planting. Tillage tools such as chisels, field cultivators, discs, sweeps, or blades are used. Weed control is accomplished with a combination of herbicides and cultivation.

5. Reduced till

Any other tillage and planting system not covered above that meets the 30 percent residue requirement.

Source: Conservation Tillage Information Center; 1983 National Survey
Conservation Tillage Practices.